Journal of Nematology 18(3):327–331. 1986.

Relative Virulence of *Meloidogyne incognita* Host Races on Soybean[1]

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Abstract: Sensitivity and host efficiency of susceptible ('Lee 68', 'Coker 156') and resistant ('Bragg', 'Centennial', 'Forrest', 'Lee 74') soybean (*Glycine max* (L.) Merr.) cultivars for races of *Meloidogyne incognita* (Mi) were determined in greenhouse experiments. Eight Mi populations collected from the southeastern United States were utilized. All Mi races reproduced readily on Lee 68 and Lee 74 and moderately on Forrest and Bragg. Coker 156 exhibited resistance to races 1 and 2, and some race 3 populations, but was very susceptible to certain race 3 and 4 populations. Reproduction of all races was lowest on Centennial. Forrest and Centennial shoot growth was not significantly suppressed by any race. There were no distinct differences in virulence between races except for a race 3 population which reproduced readily on all cultivars, stunting their growth. Considerable variation in reproduction existed within races 1 and 3.

Key words: *Glycine max*, soybean, host race, host suitability, *Meloidogyne incognita*, southern root-knot nematode, pathogenicity, resistance.

Meloidogyne incognita (Kofoid and White) Chitwood, the southern root-knot nematode, suppresses soybean (*Glycine max* (L.) Merr.) production. Nonchemical methods used to reduce nematode populations and limit crop damage include resistant cultivars and crop rotation (7,11). Selection of rotation crops is difficult, however, because of the pathogenic variation in *Meloidogyne* spp. (6,12,13,16). Resistant plants are available for only certain *Meloidogyne* species (1,2,8,10,15).

Because of pathogenic variation among populations of *M. incognita,* major efforts have been directed toward identifying populations from widely separated geographical regions using differential hosts (16,18). Existence of four host races of *M. incognita* has been demonstrated based on parasitism of cotton 'Deltapine 16' and resistant tobacco 'N.C. 95' (18).

Although pathogenic variation of *M. incognita* populations on soybean has been observed (1,3,8,9,20), variation among or within the four races needs to be determined. Gall and egg-mass ratings were used to determine resistance of soybean cultivars to *M. incognita* races 2, 3, and 4 (8). However, low gall ratings do not always relate to limited nematode reproduction (6). Egg production may be a more quan-

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Received for publication 12 July 1985.

[1] Paper Number 10003 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh. This research was supported in part by USDA CSRS Grant No. 89-106. Use of trade names in this publication does not imply endorsement.

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The authors thank DeWitt Byrd, Donald Corbett, and Kathy Forrest for technical assistance.

TABLE 1. Designations of *Meloidogyne incognita* populations by number, state of origin, and host race.

Population no.	State of origin	Host race
68*	North Carolina	1
78*	Georgia	1
424*	North Carolina	1
358*	North Carolina	2
534*	Texas	3
553*	Alabama	3
H1†	Georgia	3
401*	North Carolina	4

* Source of culture was the International Meloidogyne Project collection at North Carolina State University.

† Source of culture was R. S. Hussey, University of Georgia.

titative measure of resistance than gall ratings.

Knowledge of the potential race specificity of *M. incognita* to soybean is essential for developing rotations and breeding resistant soybeans for managing this nematode. Our objective was to determine the sensitivity and host efficiency of six soybean cultivars to *M. incognita* races originating from different geographical areas of the southeastern United States.

MATERIALS AND METHODS

Eight populations of *M. incognita* representing the four host races from various states in the southeastern United States were selected (Table 1). The International Meloidogyne Project (IMP) collection at North Carolina State University was the source of seven populations, and a race 3 population (H1) was obtained from Dr. R. S. Hussey, University of Georgia. The H1 population was a composite culture of three nematode populations collected from Florida, Georgia, and South Carolina. All populations from the IMP collection were cytological race A (19). Inoculum was increased on tomato (*Lycopersicon esculentum* Mill. 'Manapal') in the greenhouse. After 8–10 weeks, eggs were collected from tomato roots using NaOCl (5).

Soybeans evaluated included two susceptible ('Lee 68', 'Coker 156') (2) and four resistant ('Bragg', 'Centennial', 'Forrest', 'Lee 74') (4,10) cultivars. Seeds were coated with a commercial preparation of *Rhizobium japonicum* (Kirchner) Buchanan and germinated in vermiculite. After 5 days, seedlings were transferred to 15-cm-d clay pots, two to a pot, containing a potting mixture of steam-sterilized sandy loam soil and river sand (1:1). Soil in each pot was infested by pipetting a water suspension containing 10,000 eggs over the root system. Noninoculated checks for each cultivar were included to determine the influence of the nematode populations on plant growth. Splash guards made from Duropane (Warp Bros., Chicago, Ill.) were placed around each pot to prevent contamination. Fourteen hours of supplemental lighting was supplied with 1,000-W multi-vapor lamps. Plants were grown at an average temperature of 29 ± 4 C.

After 90 days, soybean shoots were harvested, dried, and weighed. At harvest roots were carefully washed free of soil and cut into 1-cm segments. Eggs were extracted from half of the root systems from each pot using NaOCl (5) and counted. The experiment was repeated at an average temperature of 28 ± 5 C.

The experiment was factorially arranged with a randomized complete block design with three replications per nematode population for each soybean cultivar. Analysis of variance was performed on all data to determine cultivar effects, population effects, and cultivar-by-population interaction. Oostenbrink's (14) R factor (RF = final egg counts per initial egg inoculum density) was determined for each nematode–cultivar treatment.

RESULTS AND DISCUSSION

The *M. incognita* populations reproduced readily on Lee 68 and Lee 74, with reproduction factors (RF) ranging from 15.8 to 47.5 and 5.3 to 46.5, respectively (Table 2). Coker 156 was a good-to-fair host for populations H1 (host race 3) and 401 (host race 4) but allowed little reproduction of the other populations. Forrest and Bragg were generally suitable hosts for all populations, with RF ranging from 1.6 to 33.3 and from 2.4 to 40.3, respectively. Reproduction was limited on Centennial for all but the H1 population. Except on Lee 68, H1 population reproduction was much greater than reproduction of any other population. All cultivars except Centennial were excellent hosts for the 401 (host race 4) population. There was a significant interaction between cultivars and populations for reproduction ($P = 0.01$).

TABLE 2. Reproduction of *Meloidogyne incognita* populations on susceptible and resistant soybean cultivars.

M. incognita host race		RF value/cultivar*					
Race	Population no.	Lee 68†	Coker 156†	Lee 74‡	Forrest‡	Bragg‡	Centennial‡
1	68	19.0 ab	0.5 b	7.0 b	4.4 bc	4.8 cd	0.4 c
1	78	15.8 ab	1.7 b	5.3 b	1.6 bc	3.6 cd	0.3 c
1	424	17.1 ab	1.3 b	14.5 b	12.9 b	21.1 b	3.3 b
2	358	47.5 a	2.4 b	8.7 b	6.0 bc	3.8 cd	3.4 b
3	553	21.2 ab	1.6 b	13.6 b	8.0 bc	19.0 bc	1.4 bc
3	534	17.3 ab	1.8 b	6.4 b	1.7 bc	2.4 d	1.3 bc
3	H1	24.3 ab	65.7 a	46.5 a	33.3 a	40.3 a	18.8 a
4	401	38.6 ab	8.7 b	16.8 b	8.5 bc	9.2 bcd	1.7 bc

Variable	ANOVA F = value (probability level)
Cultivars	11.40 ($P = 0.0001$)
Populations	17.59 ($P = 0.0001$)
Cultivars × populations	2.01 ($P = 0.0003$)

Means within columns followed by the same letter do not differ significantly at $P = 0.05$ by Waller-Duncan K-ratio t-test.

* RF (reproduction factor) = final egg counts/initial population density.

† Soybean cultivars reported to be susceptible to *M. incognita*.

‡ Soybean cultivars reported to be resistant to *M. incognita*.

Shoot growth of Lee 68 and Lee 74 generally was suppressed by all *M. incognita* populations (Table 3). Coker 156 was tolerant to all populations except to race 3 populations 534 and H1 and to the race 4 population. Shoot growth of Forrest and Centennial was not suppressed ($P = 0.05$) by any population. The cultivar-by-population interaction was significant ($P = 0.05$) for shoot growth.

There were no distinct differences in virulence among host races except for the H1 population (race 3) which was very aggressive on all cultivars. Variation existed within races, with populations 424 and H1 the most virulent of races 1 and 3, respectively.

Our findings disagreed with earlier reports of soybean cultivar resistance to *M. incognita*. Lee 74 and Bragg, which have been reported as resistant to this nematode (4,8,10), showed little resistance to any of the host races. Variability among tests

TABLE 3. Effects of *Meloidogyne incognita* populations on shoot growth of susceptible and resistant soybean cultivars.

M. incognita host race		Dry shoot weight (g)/cultivar					
Race	Population no.	Lee 68*	Coker 156*	Lee 74†	Forrest†	Bragg†	Centennial†
Check		32.0 a	35.8 a	33.1 a	38.1 a	32.0 a	32.1 ab
1	68	12.3 bc	32.1 ab	20.5 ab	32.6 a	26.3 abc	42.1 a
1	78	12.6 bc	37.8 a	23.3 ab	40.5 a	23.8 abc	33.5 ab
1	424	5.6 c	35.6 ab	21.0 ab	32.8 a	20.5 abc	33.5 ab
2	358	10.0 bc	29.5 abc	25.0 ab	30.1 a	22.8 abc	36.0 ab
3	553	16.1 b	36.0 a	20.8 ab	26.8 a	28.0 ab	29.1 b
3	534	9.3 bc	25.6 bc	24.5 ab	29.5 a	18.0 bc	29.8 b
3	H1	5.6 c	10.0 d	18.1 b	25.5 a	15.6 c	26.1 b
4	401	8.5 c	19.6 cd	15.1 b	31.3 a	21.6 abc	26.8 b

Variable	ANOVA F = value (probability level)
Cultivars	46.87 ($P = 0.0001$)
Populations	10.64 ($P = 0.0001$)
Cultivars × populations	1.61 ($P = 0.0003$)

Means within columns followed by the same letter do not differ significantly at $P = 0.05$ by Waller-Duncan K-ratio t-test.

* Soybean cultivars reported to be susceptible to *M. incognita*.

† Soybean cultivars reported to be resistant to *M. incognita*.

(1,4,8,10) for determining resistance of cultivars to *M. incognita* is probably caused by differences in virulence among populations used. Screening cultivars with a mixture of aggressive populations to select for a broader range of resistance has been suggested (6).

Soybean resistance to *M. incognita* has been reported to be race specific (17). A race 2 population was reported to reproduce more readily on Centennial than populations of races 1, 3, and 4, but the reproduction pattern of these populations was opposite on Pickett 71 (17). We found, however, that reproduction of race 1 and 3 populations was equal to, or greater than, that of a race 2 population on Centennial. Variation in reproduction within races 1 and 3 was common on several cultivars. Soybean resistance appears to be population specific but not race specific. These results are not surprising, since soybean is not used to identify races in the North Carolina Differential Host Test (18). Using populations selected for virulence rather than race should be sufficient for evaluating cultivars for resistance.

Soybean cultivars should be chosen carefully for crop rotations. Cultivars whose growth appears to be unaffected by *M. incognita* may actually be suitable hosts for the nematode. Lee 74 and Bragg, which were reported to have resistance to some populations, were suitable hosts for all the populations included in this study. A large increase in the nematode population one year would make crop rotation an ineffective management tactic leading to decreased yields the following year. Even though *M. incognita* increased on Forrest and Centennial, these cultivars were tolerant to all races. Both cultivars are also resistant to *Heterodera glycines* Ichinohe races 1 and 3, and Forrest is resistant to *Meloidogyne arenaria* (Neal) Chitwood and *M. javanica* (Treub) Chitwood (4,8,10,15). These cultivars, in crop rotation, should provide excellent management of most populations of *M. incognita.* Application of nematicides may be necessary in fields infested with highly virulent populations such as H1.

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